

WHAT IS CLAIMED IS:

1. A MEMS switch comprising:

a substrate defining a plane;

first and second switch contacts;

a contact shuttle that is movable in a linear path between first and second switch state positions with respect to the switch contacts;

a spring biasing the contact shuttle to the first switch state position;

a plurality of moving electrodes coupled to the contact shuttle and having generally planar major surfaces perpendicular to the plane of the substrate; and

a plurality of fixed electrodes, each located interleaved with and adjacent to one of the moving electrodes, having generally planar major surfaces perpendicular to the plane of the substrate, wherein in response to the application of an electric actuation voltage, electrostatic forces develop between the moving and fixed electrodes causing the moving electrodes to move along an axis parallel to the plane of the substrate and perpendicular to the planar major surfaces of the electrodes, thereby forcing the contact shuttle to move to the second switch state position along the axis parallel to the plane of the substrate and perpendicular to the planar major surfaces of the electrodes.

2. The MEMS switch of claim 1 wherein the contact shuttle is electrically isolated from the moving and fixed electrodes.

3. The MEMS switch of claim 2 wherein the contact shuttle includes:

a polysilicon base;

a metal contact member on the base; and

native oxide between the base and metal contact member.

4. The MEMS switch of claim 1 wherein the spring includes:

a relatively rigid member connected to the contact shuttle; and

at least one resilient member connected to the relatively rigid member.

5. The MEMS switch of claim 4 wherein the moving electrodes are connected to and extend from the relatively rigid member of the spring.

6. The MEMS switch of claim 5 wherein the moving electrodes include moving electrodes connected to and extending from opposite sides of the relatively rigid member.

7. The MEMS switch of claim 6 wherein the spring includes a plurality of resilient members connected to and extending from opposite sides of the relatively rigid member.

8. The MEMS switch of claim 1 wherein the fixed electrodes and moving electrodes have major surfaces facing one another.

9. The MEMS switch of claim 1 wherein the spring includes:
a relatively rigid member connected to the contact shuttle and movable in the linear path; and
at least two resilient members connected to and extending from the rigid member.

10. The MEMS switch of claim 9 wherein the resilient members are parallel to the plane of the substrate.

11. The MEMS switch of claim 10 wherein the moving electrodes are connected to and extend from opposite sides of the rigid member.

12. The MEMS switch of claim 11 wherein the moving electrodes include at least two electrodes on both opposite sides of the rigid member.

13. The MEMS switch of claim 12 wherein the spring is a parallelogram structure.

14. The MEMS switch of claim 1 wherein the spring is parallelogram structure including:

a relatively rigid member connected to the contact shuttle and movable in the linear path;

first and second end members extending from the rigid member at spaced-apart locations;

a first side member connected to and extending between the first and second end members on a first side of the rigid member;

a second side member connected to and extending between the first and second end members on a second side of the rigid member;

a first support arm having a first end connected to the first side member and a second end connected to the substrate; and

a second support arm having a first end connected to the second side member and a second end connected to the substrate.

15. The MEMS switch of claim 1 wherein:

the second end of the first support arm is located between the rigid member and the first side member; and

the second end of the second support arm is located between the rigid member and the second side member.

16. The MEMS switch of claim 1 wherein the first and the second switch contacts are positioned adjacent to but are electrically isolated from one another to form a concave gap that opens toward the contract shuttle.

17. The MEMS switch of claim 16 wherein the contact shuttle is a convex member that is sized and shaped to extend into the concave gap between the first and the second switch contacts.

18. The MEMS switch of claim 16 wherein the first and the second switch contacts have planar faces to form a V-shaped gap that opens toward the contact shuttle.

19. The MEMS switch of claim 18 wherein the contact shuttle is a triangularly-shaped member that is sized and shaped to extend into the V-shaped gap between the first and the second switch contacts.

20. A MEMS switch, including:

a substrate;

a contact shuttle movable with respect to the substrate between switch state positions;

a plurality of moving electrodes coupled to the contact shuttle at spaced-apart

locations and having generally planar major surfaces facing each other to form a comb structure; and

a plurality of fixed electrodes coupled to the substrate at spaced-apart locations and having generally planar major surfaces facing each other to form a comb structure, the fixed electrode comb structure interleaved with the moving electrode comb structure, wherein in response to the application of an electric actuation voltage, electrostatic forces develop between the moving and fixed electrodes causing the major surfaces of the moving electrodes to move with respect to the major surfaces of the fixed electrodes, thereby forcing the contact shuttle to move between the switch state positions along a longitudinal axis parallel to the substrate and perpendicular to the planar major surfaces of the electrodes.

21. The MEMS switch of claim 20 and further including:

a member connected to the contact shuttle; and

wherein the moving electrodes are mounted to the member.

22. A MEMS switch, including:

switch contacts;

a driven member;

a contact shuttle connected to the driven member and movable between switch state positions with respect to the switch contacts; and
oxide insulator for electrically isolating the contact shuttle and the driven member.

23. The MEMS switch of claim 22 and further including an isolation mount connecting the contact shuttle to the driven member, including:

a retainer member fixedly connected to one of the contact shuttle and driven member;
and

an engaging member fixedly connected to the other of the contact shuttle and driven member, the engaging member free from fixed connection to but retained by the retainer member, and wherein adjacent surfaces of the contact shuttle, retainer member and engaging member are coated with the oxide insulator.

24. A MEMS switch comprising:

first and second switch contacts positioned adjacent to and electrically isolated from one another to form a concave gap;

a convex contact shuttle sized and shaped to extend into the concave gap and movable in a linear path between first and second switch state positions with respect to the switch contacts; and

an electrostatic actuating mechanism for driving the contact shuttle between the first and the second switch state positions.

25. The MEMS switch of claim 24 wherein the first and the second switch contacts have planar faces to form a V-shaped gap that opens toward the contract shuttle.

26. The MEMS switch of claim 25 wherein the contact shuttle is a triangularly-shaped member that is sized and shaped to extend into the V-shaped gap between the first and the second switch contacts.

27. A MEMS actuator comprising:

a substrate defining a plane;

a plurality of moving electrodes having generally planar major surfaces perpendicular to the plane of the substrate;

a plurality of fixed electrodes, each located interleaved with and adjacent to one of the moving electrodes, having generally planar major surfaces perpendicular to the plane of the substrate, wherein in response to the application of an electric actuation voltage, electrostatic forces develop between the moving and fixed electrodes causing the moving electrodes to move along an axis parallel to the plane of the substrate and perpendicular to the planar major surfaces of the electrodes; and

at least one spring for biasing the movable comb structure to a rest position upon removal of the electric actuation voltage.